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A New Shrimp of the Genus *Pandalopsis* (Decapoda: Caridea: Pandalidae) from the Eastern Pacific, with Notes on its Natural History

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A new species of pandalid shrimp, *Pandalopsis lucidirimicola*, is described. This colorful species occurs in shallow, current-swept areas of Washington State, U.S.A., and southern British Columbia, Canada. It is readily distinguished from other eastern Pacific *Pandalopsis* by a number of characters including an unusually large number of carpus articulations of the second pereopod and a relatively short outer antennular flagellum and rostrum. Juveniles often associate with the sea urchin *Strongylocentrotus franciscanus*, while adults reside in deep crevices and under boulders. Like many other species in the genus, it appears to be a protandric hermaphrodite.
Key Words: *Pandalopsis lucidirimicola*, Pandalidae, Eastern Pacific, new species.

Introduction

The genus *Pandalopsis* Bate, 1888 contains a number of large shrimps of current and potential economic importance. Although all of the species of *Pandalopsis* have been reported from the North Pacific Ocean, by far the greatest diversity occurs in the northwestern region, where 11 of the 14 known species have been found (Komai 1994). In contrast, only two species are known from the entire Pacific coast of Canada and the contiguous United States. The commercially important sidestripe shrimp *P. dispar* Rathbun, 1902 ranges from the Bering Sea to Oregon (Butler 1980), while *P. ampla* Bate, 1888 (originally described from the southeastern Atlantic) occurs both in the Bering Sea and from Washington State to Acapulco, Mexico (Hendrickx and Wicksten 1989), although it is not certain the Atlantic and Pacific specimens represent the same species (Takeda and Hatanaka 1984). Two additional species (*P. aleutica* Rathbun, 1902 and *P. longirostris* Rathbun, 1902) have been reported from the Aleutian Islands.

Most *Pandalopsis* inhabit the deeper part of the continental shelf or continental slope (Butler 1980; Komai 1994); however, dive surveys of shallow, current-swept areas in northern Washington State, U.S.A., and southern British Columbia, Canada, revealed the presence of a brilliantly-colored, previously unknown member of the genus residing in crevices and fissures of rock walls, underneath large boulders, and in association with the giant red sea urchin *Strongylocentrotus franciscanus* (A. Agassiz, 1863).

Drawings were made of exuvia from captive specimens using a camera lucida on a Wild M5 stereomicroscope, and counts of carpus articles were taken from specimens and from exuvia recovered from the aquaria. Behavioral observations were made over a period of nine months on specimens maintained in refrigerated (10-12℃) closed-system aquaria, and while diving using SCUBA.

Pandalopsis lucidirimicola sp. nov.
(Figs 1-5)

Material examined. Holotype: transitional male, postorbital carapace length (CL) 12.8mm, Point Atkinson, Burrard Inlet, British Columbia, Canada (49° 19'N, 123° 15'W), 18m depth, under large rocks, 5 May 1996, D. Kent and G.C. Jensen coll., National Museum of Natural History, Smithsonian Institution (USNM 284144), collected as male and raised in captivity. Allotype: CL 17.2mm, McKenzie Bight, Saanich Inlet, Vancouver Island, British Columbia, Canada (48° 33.5'N, 123° 30'W), 18-22m depth, in crevice, 9 February 1997, D. Kent and J. Fisher coll. (USNM 260800). Paratypes: three males (CL 5.8-7.3mm), Burrows Channel, Anacortes, Washington, USA (48° 29.5'N, 122° 41.5'W), 15m depth, partially beneath large *Strongylocentrotus franciscanus*, 7 September 1996, G.C. Jensen coll. (USNM 284145); two males (CL 6.7, 8.5mm), same location and date, California Academy of Sciences (CAS 107383); two males (CL 6.35, 7.4mm), same location and date, National Science Museum, Tokyo (NSMT Cr12150); one male (CL 6.4mm), same location and date, British Columbia Provincial Museum (no. 997-00069-1); one male (CL 7.95mm), Matthew Point, Galiano Island, British Columbia, Canada (48° 51.6'N, 123° 19.7'W), 17-18m depth, 24 November 1995, D. Kent coll., British Columbia Provincial Museum (no. 997-00068-1). All Burrows Channel paratypes were collected as juveniles and raised in captivity for four months.

Additional Material. Three males (CL 6.4-7.2mm), Burrows Channel, Anacortes, Washington, USA (48° 29.5'N, 122° 41.5'W), 22m depth, partially beneath large *Strongylocentrotus franciscanus*, 4 October 1996, G.C. Jensen coll., School of Fisheries, University of Washington; two juveniles (CL 4.7mm), same location, 12m depth, with *S. franciscanus*, 22 July 1996, G.C. Jensen coll., School of Fisheries, University of

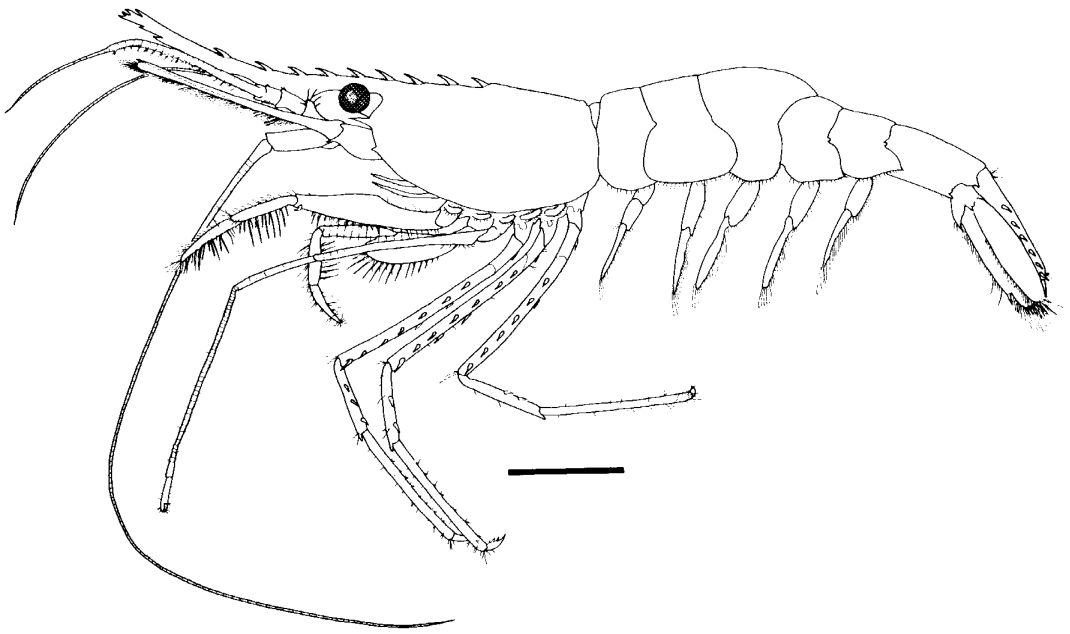

Fig. 1. *Pandalopsis lucidirimicola* sp. nov. Exuvium from holotype, male; eye added. Scale bar equals 5mm.

Washington.

Description. Integument naked, smooth, without transverse patch of setae near posterior margin of carapace. Rostrum (Fig. 2a) with little or no arch over eyes, distal two-thirds strongly ascending, 1.25-1.6 times carapace length, dorsal margin with 10-13 spines including two or three (usually two) subdistal teeth; three or four spines on carapace posterior to orbit with posteriormost situated at or near midlength of carapace, all dorsal spines movable except for subdistal spine and sometimes one or two anterior spines with incomplete or no basal suture; subdistal 0.3-0.52 of dorsal margin unarmed; ventral margin with 7-10 teeth, posteriormost smaller than preceding tooth.

Abdominal somites smooth; pleura of first three somites broadly rounded, fourth to sixth somites with posteroventral tooth, sixth somite 0.43-0.57 times as long as carapace. Telson (Fig. 2d, e) 0.63-0.88 of carapace length, armed with 5-7 pairs of dorsolateral spines and three pairs of posterior spines.

Eye (Fig. 3b) with cornea darkly pigmented, ocellus distinct; maximum diameter 0.13-0.24 of carapace length, ratio decreasing with increased size.

Antennular peduncle (Fig. 2b) reaching to 0.36-0.45 of scaphocerite length, with 0-8 dorsodistal spinules and several long, plumose setae on the basal article, 0-5 dorsodistal spinules on second article; stylocerite broad and rounded, usually with minute terminal spine; outer flagellum 0.8-1.5 times carapace length; inner flagellum 1.2-1.8 times carapace length.

Scaphocerite (Fig. 2c) narrow, 1.0-1.3 times carapace length and 6-9 times as long as wide, reaching distal one-sixth of rostrum; lateral margin strongly concave;

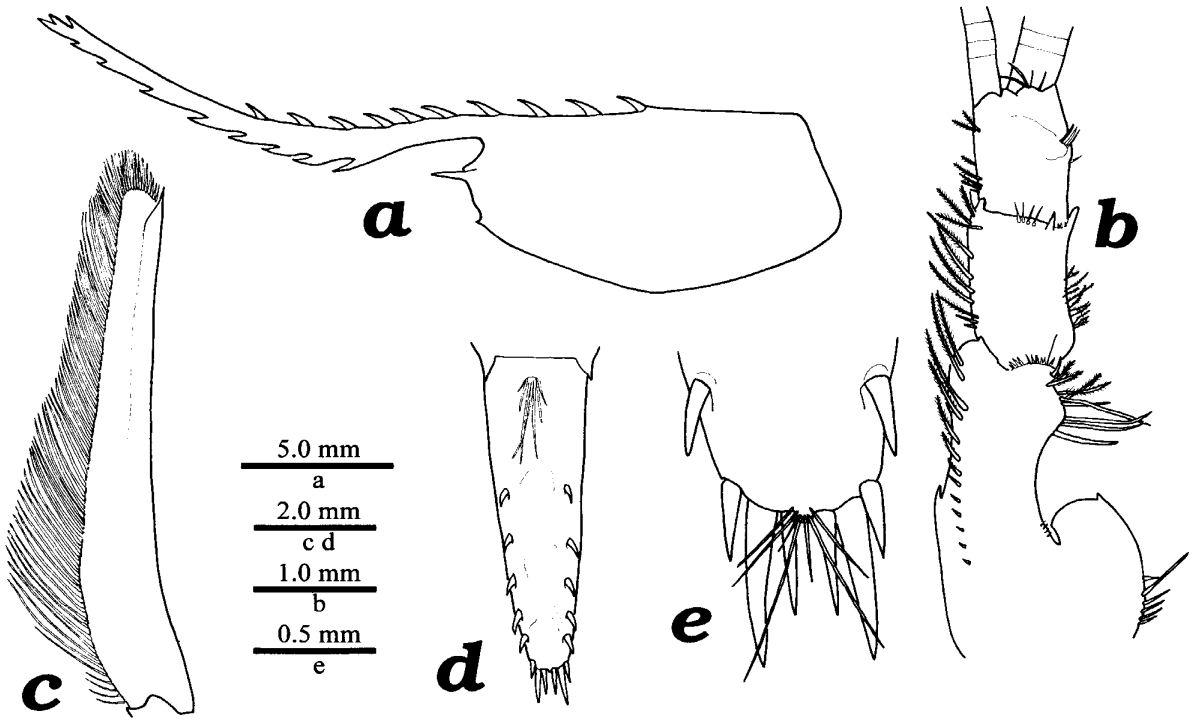

Fig. 2. *Pandalopsis lucidirimicola* sp. nov. a, holotype exuvium at CL 10.5mm; b-e holotype exuvium at CL 8.5mm. a, lateral view of carapace and rostrum; b, antennular peduncle, dorsal; c, scaphocerite, dorsal; d, telson, dorsal; e, posterior margin of telson, dorsal.

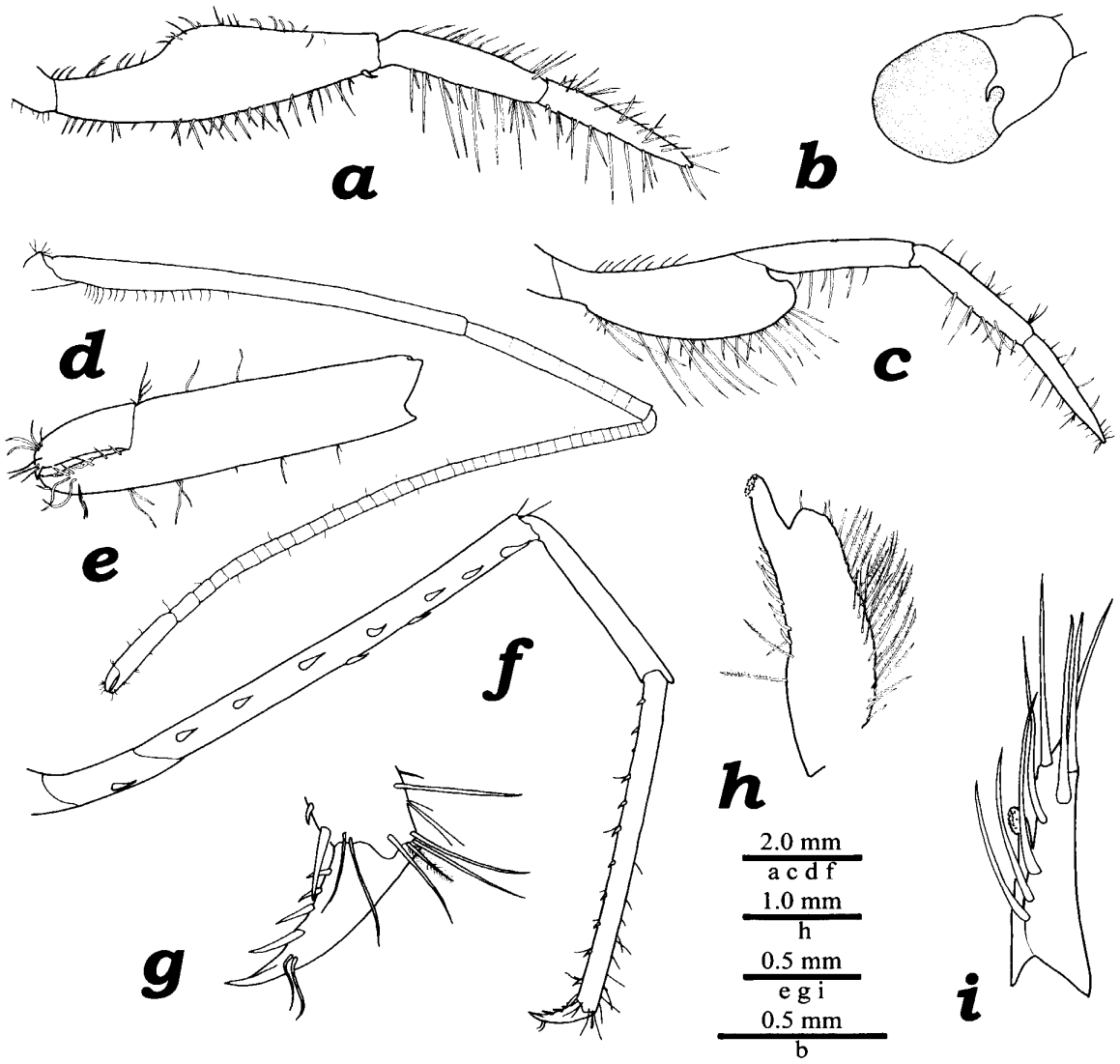

Fig. 3. *Pandalopsis lucidirimicola* sp. nov. a, c-g, holotype exuvium at CL 8.5mm; b, male paratype, CL 7.95mm, British Columbia Provincial Museum no. 997-00068-1; h, i, holotype exuvium at CL 10.5mm. a, third maxilliped, lateral; b, eye; c, first pereopod, lateral; d, second pereopod, lateral; e, chela of second pereopod; f, third pereopod, lateral; g, dactyl of third pereopod, lateral; h, endopod of first pleopod of male; i, appendix interna and appendix masculina of second pleopod.

distomesial margin of blade produced but exceeded by spine; antennal flagellum 4.0-6.3 times carapace length.

Third maxilliped (Fig. 3a) relatively stout, reaching from slightly beyond middle of scaphocerite to near end of scaphocerite; epipod present, exopod absent; ultimate and penultimate segments subequal, densely setose; antepenultimate segment with curved distolateral spine.

First to fourth pereopods each with epipod bearing terminal hook. First pereopod (Fig. 3c) minutely chelate, short of or just reaching midpoint of scaphocerite, propodus subequal to or slightly shorter than carpus and reaching middle of ultimate segment of third maxilliped; ischium with broad ventral laminar

expansion. Second pereopods (Fig. 3d) subequal, exceeding scaphocerite by length of propodus and up to half of carpus length; chela (Fig. 3e) with dactyl 0.3-0.4 times as long as palm in males, 0.7 times in female; carpus with 21-35 articulations in sexually undifferentiated juveniles and 31-43 articulations in adults (Fig. 5), merus with 0-10 rudimentary articulations, ischium with 0-5 rudimentary articulations. Third to fifth pereopods long and slender; dactyls laterally compressed. Third pereopod (Fig. 3f) overreaching scaphocerite by length of dactyl and one-third of propodus; dactyl (Fig. 3g) 0.13-0.18 of propodus length and with 3-5 spinules over entire length of flexor margin (partial spinule on inside of terminal claw becomes separate spinule with growth); propodus 15-19 times longer than wide, with total of 9-18 spinules in two rows; carpus 0.49-0.72 of propodus length, armed with two or three lateral spines; merus 0.93-1.00 of carapace length, with six or seven lateral spines and 0-3 (usually three) flexor spines, including strong distal spine. Fourth pereopod overreaching scaphocerite by dactyl and end of propodus; dactyl similar to that of third pereopod, 0.14-0.17 of propodus length, with four or five spinules over entire length of flexor margin; propodus length 15-19 times width, with total of 10-17 flexor spinules in two rows; carpus 0.48-0.67 of propodus length, with 2-3 (usually three) lateral spines; merus 0.81-0.97 of carapace length, with six or seven lateral spines and 1-4 flexor spines, including a strong distal spine. Fifth pereopod overreaching scaphocerite by dactyl or half of dactyl; dactyl 0.12-0.14 of propodus length, with 3-5 flexor spinules over entire length of flexor margin; propodus length 18-21 times width, flexor margin with total of 9-16 spinules in two rows; carpus 0.49-0.62 of propodus length with one or two lateral spines; merus 0.73-0.90 of carapace length, with 5-7 lateral spines and 0-1 flexor spines, none distal.

Endopod of first pleopod of sexual male (Fig. 3h) subovate; appendix interna fairly broad and separated from distolateral lobule by deep incision. In female, endopod with distal one-third tapered, mesial margin with eight small spines in proximal half. Endopod of second pleopod of sexual males with appendix masculina (Fig. 3i) exceeding appendix interna by one-fourth of the latter's length and bearing 8-10 long spines; in transitional male holotype, appendix masculina shorter than appendix interna and bearing several spinules; in female appendix masculina completely reduced.

Coloration. Conspicuously marked with bright red or dark purple horizontal stripes on translucent background (Fig. 4). Numerous brilliantly reflective white or yellow dots forming consistent pattern on body and appendages; largest dots in pairs on posterolateral margins of carapace and third abdominal somites, as single dorsal dots on second, third, and sixth abdominal somites, and on the basal segments of uropods. Tips of rostrum and telson white; antennal flagella with broad white bands and joints of pereopods with narrow white bands.

Distribution. Keystone, Whidbey Island, Washington, U.S.A. (48° 09'N, 122° 40'W) to Husser Point, Nigei Island, British Columbia, Canada (50° 52'N, 127° 48'W); 7-23m depth, residing in deep rock crevices, under boulders, and in association with large sea urchins.

Etymology. The specific name is derived from the Latin *lucid* (glittering) in reference to the reflective white markings, and *rimicola* (crevice-dweller).

Remarks. *Pandalopsis lucidirimicola* does not appear to be closely related to any other known member of the genus, and can be recognized by a number of different features. It has a relatively short rostrum and unusually long scaphocerite (1.0-1.3

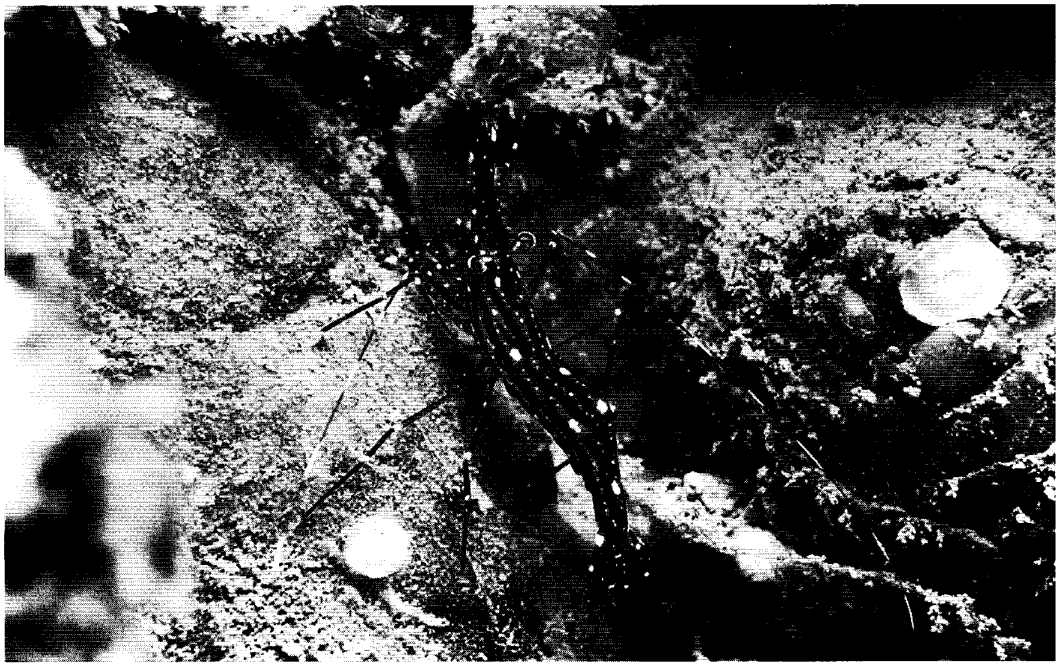

Fig. 4. *Pandalopsis lucidirimicola* sp. nov. *In situ* photograph of live specimen, Burrows Channel, Anacortes, Washington, 4 October 1996, 21m depth. Specimen 7-8mm postorbital carapace length.

times the carapace length), resulting in the rostrum overreaching the scaphocerite by only one-sixth or less of its length as compared to one-fourth to two-thirds of the rostrum length in other species. The outer flagellum of the antennule is shorter than the inner flagellum and proportionately much shorter (0.8-1.5 times the carapace length) than in other eastern Pacific species, where the outer flagellum is at least 2.5 times the carapace length and much longer than the inner.

Like *P. dispar, P. lucidirimicola* is set apart from the rest of the species in the genus by having the carpus of the second leg divided into an unusually large number of articles. *Pandalopsis* spp. typically have equal second pereopods with the carpus divided into less than 25 articles (Komai 1994); however, *P. dispar* has 26-33 articles (Rathbun 1902; Butler 1980) and there are up to 43 in *P. lucidirimicola*. The number appears to increase with size in the new species until sexual maturity, when more than 30 articulations are present (Fig. 5). *Pandalopsis lucidirimicola* differs from *P. dispar* in many respects besides those noted above, having laterally compressed dactyls on pereopods 3-5 instead of the atypical, dorsoventrally flattened dactyls of *P. dispar*, and having a proportionately shorter rostrum (1.3-1.6 versus 1.6-2.8 times the carapace length; Butler 1980). The two species also differ in color and habitat, *P. dispar* being pale orange with irregular longitudinal white markings on the abdomen and lacking reflective white markings, and occurring on soft bottoms in comparatively deep water (Butler 1980; Jensen 1995).

The combination of its reclusive behavior and often inaccessible habitat makes *P. lucidirimicola* very difficult to collect and probably accounts for this distinctive species escaping detection for so long. Many of the locations where it has been observed have extremely strong tidal currents that severely constrain the frequency

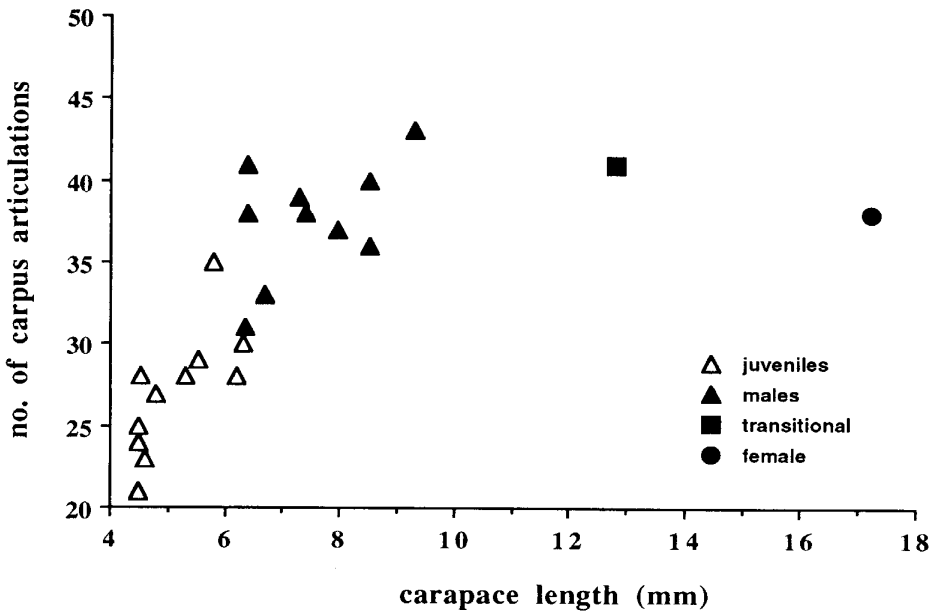

Fig. 5. *Pandalopsis lucidirimicola* sp. nov. Variation with size in number of articles in carpus of second pereopod for different sexual phases.

and duration of dive operations, and once sighted, they retreat into the deepest recesses of the crevice while performing an exaggerated side-to-side rocking motion. Trawls, dredges, and other conventional gear are ineffective for sampling these vertical rock faces and boulder fields and, like *P. dispar*, this species does not respond to baited traps (Butler 1980). Captive specimens have shown little response to food scents but are very adept at capturing amphipods and other small crustaceans. The elongate second pereopods and the long setae on the third maxillipeds are extremely sensitive to touch, and when lightly brushed by a smaller organism the shrimp pounces and envelops its prey with the third maxillipeds and the first pair of pereopods. The laminate ventral expansions on the ischia of the first pereopods help hold the prey to the mouth, where it is ingested whole. *P. lucidirimicola* may capture prey largely by ambush since it is rarely seen venturing beyond the opening of its shelter; this is in sharp contrast to *Pandalus danae* Stimpson, 1857 and *P. stenolepis* Rathbun, 1902, species that co-occur in the same areas and emerge from crevices to forage at night.

Small specimens of *Pandalopsis lucidirimicola* often associate with the red sea urchin *Strongylocentrotus franciscanus*, and as many as five shrimp have been found beneath the spine canopy of a single large urchin. Juveniles residing with urchins typically have dark purple markings rather than red ones. As with hippolytid shrimps (Bauer 1981), the reddish coloration is due to the expansion of chromatosomes in the underlying epidermis; specimens can quickly become very pale when stressed, and the exuviae from red specimens are colorless. In contrast, the pigmentation of purple specimens is actually incorporated into the exoskeleton and shed with the molt, and those held in captivity in the absence of sea urchins lost their purple color after one or two molts. This suggests that the shrimp acquires pigment from the urchins in some manner; however, purple specimens have been sighted in areas that seem to lack urchins.

The small *P. lucidirimicola* living in association with sea urchins are far more accessible than the crevice-dwelling adults, hence most specimens collected were sexually undifferentiated juveniles. These all subsequently developed into males in captivity, suggesting that this species is a protandric hermaphrodite as has been demonstrated or suspected for some other members of the genus (Berkeley 1930; Butler 1980; Komai 1994). The largest specimen captured to date was the allotype female, which was ovigerous at a carapace length of 17.2mm, while the holotype, which had a well-developed appendix masculina when captured, was clearly in a transitional state when preserved eight months later at a length of 12.8mm. Although size data are lacking for a few species, most *Pandalopsis* spp. are considerably larger when transitional (24-30mm CL); therefore, *P. lucidirimicola* may be one of the smallest members of the genus.

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